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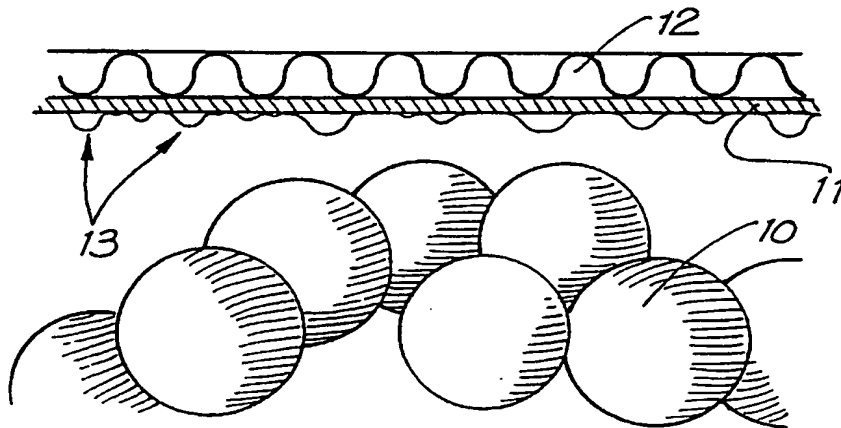
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<b>(21) International Application Number:</b> PCT/AU93/00398 <b>(22) International Filing Date:</b> 4 August 1993 (04.08.93) <b>(30) Priority data:</b> PL 3988 6 August 1992 (06.08.92) AU <b>(71) Applicant (for all designated States except US):</b> COMMON-WEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION [AU/AU]; Limestone Avenue, Campbell, ACT 2061 (AU). <b>(72) Inventors; and</b> <b>(75) Inventors/Applicants (for US only) :</b> PATTERSON, Brian, David [AU/AU]; 1485 Ourimbah Creek Road, Ourimbah, NSW 2258 (AU). JOYCE, Daryl, Clifford [AU/AU]; 10 Henry Street, Chapel Hill, QLD 4069 (AU).	<b>(74) Agent:</b> F.B. RICE & CO.; 28A Montague Street, Balmain, NSW 2041 (AU). <b>(81) Designated States:</b> AU, CA, JP, KR, NZ, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). <b>Published</b> <i>With international search report.</i>	

**(54) Title:** A PACKAGE ALLOWING COOLING AND PRESERVATION OF HORTICULTURAL PRODUCE WITHOUT CONDENSATION OR DESICCATION



**(57) Abstract**

The present invention provides a packaging material for use in packaging horticultural produce. The packaging material of the present invention comprises a first sheet which is impermeable to water vapour and liquid water and a film which is capable of absorbing at least 10 % of its weight of water from liquid water after being equilibrated with an atmosphere saturated with water vapour. In preferred forms of the invention the film comprises a layer of fibrous hydrophilic materials such as paper made from cellulose fibre or other hydrophilic fibres. Alternatively, the film comprises a polymer of polyvinyl alcohol which is able to absorb water from the vapour and from the liquid phase to form a water-swellaable gel. The film may be bonded to the first sheet or it may be free. The present invention also provides a method of packaging produce involving the use of this packaging material.

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Exhibit 4

A PACKAGE ALLOWING COOLING AND PRESERVATION OF  
HORTICULTURAL PRODUCE WITHOUT CONDENSATION OR  
DESICCATION

5       The present invention relates to a packaging  
material and to a method of packaging horticultural  
produce. The packaging material and method of packing  
of the present invention enable the cooling of living  
horticultural produce within the packaging material  
with a greater than 90% reduction over current methods  
10       in the condensation of water on the packed produce.

      When horticultural produce is harvested it begins  
to deteriorate. The process of deterioration can be  
retarded by cooling the produce as soon as possible  
after harvest. Products that are relatively resistant  
15       to cold are cooled to temperatures as close as  
practicable to their freezing point, while many  
tropical fruits, vegetables and flowers are cooled to  
temperatures of 15°C or less. During subsequent  
storage and transport to distant markets, the produce  
20       is preferably maintained at a temperature as low as  
possible, consistent with the resistance to cold of the  
particular produce.

      In current practice, a number of different  
techniques of cooling and methods of packaging are  
25       used. Whatever methods are used, their sequence is  
relevant to the invention described here.

      In the first procedure, the produce, which may be  
a fruit, vegetable, harvested ornamental or a plant  
still attached to its roots, is cooled before being  
30       packaged to a temperature that approaches the optimum  
temperature for storage. For many products, this will  
be a temperature close to 0°C. The produce is then  
packaged in a way that protects the produce during  
subsequent storage and transport.

In the second procedure, the reverse sequence is used, with the produce being packaged before being cooled.

Whether one or the other sequence is used depends  
5 on the nature of the crop, the length of storage desired and the facilities available. If condensation is likely to harm the commodity, the first sequence is to be preferred. However, a number of considerations often make it difficult or impossible to achieve in  
10 current practice. These considerations are detailed below.

1. If the produce is cooled before packing, it will tend to warm during packing. To prevent this, the packing operation should be performed at the  
15 temperature of storage. However, packers must be paid higher rates to work at such low temperatures and in any case the provision of controlled temperatures in a packing area is expensive.

2. If the produce is destined for extended storage,  
20 dehydration must be prevented by using packaging that is a barrier to the loss of water. This will result in relative humidities around the produce of 98% or greater. Under these circumstances, water will condense in the package if the produce has warmed  
25 during packing. This condensation damages many commodities and encourages diseases such as rots that destroy the commodity.

3. Because packers are reluctant to work at low temperature or because facilities are too expensive to  
30 install, much precooled produce is packed at temperatures higher than the storage temperature.

Under such conditions, moisture condenses on the fruit. This can damage the commodity in many ways and shorten its post-harvest life.

35 Because of the considerations outlined above, the second sequence, of packing before cooling, is often

adopted. This is in general simpler and less expensive, but introduces a number of other problems, as outlined below.

- 5 1. If a warm commodity is cooled within a package, the package generally has a smaller heat capacity than the horticultural commodity. During the cooling process, the commodity will generally be at a higher temperature than the package. Under such circumstances, moisture will evaporate from the  
10 commodity to the packaging. If this moisture is not dissipated, the commodity will be harmed. In order to dissipate the moisture, the package must have holes that allow bulk exchange of air during cooling.
- 15 2. During extended storage or transport of horticultural produce, the packaging must be such as to prevent excessive loss of moisture. However, for the reasons outlined above, packaging in which produce is cooled must allow free loss of moisture. As a result,  
20 cooling within the package, although often to be preferred on grounds of economy, is not suitable for commodities that must be stored for extended periods without loss of moisture.

In summary, the current practices of handling that concern the cooling and packaging of horticultural  
25 produce involve several compromises. The need to cool the produce efficiently must be reconciled with the need for a package appropriate to the conditions of storage. At the same time, the economic restraints set by the conditions of work for the packers and the  
30 expense of providing refrigerated packing areas must be considered. When these factors are considered together, an overall conclusion concerning current practice is arrived at. This is, that packing before cooling is to be preferred over cooling before packing,  
35 but technical innovation is needed to overcome the problem of condensation. Otherwise, the package is not

likely to prevent the loss of water during extended storage.

5 The present invention consists in a packaging material for use in packing horticultural produce, the packing material comprising a first sheet which is impermeable to water vapour and liquid water and a film which is capable of absorbing at least 10% of its weight of water from liquid water after being equilibrated with an atmosphere saturated with water vapour.

10 In a first preferred embodiment the film comprises a layer of fibrous hydrophilic material such as paper made from cellulose fibres or other hydrophilic fibres. This layer may be bonded to the first sheet, or it may be free.

15 In a second preferred embodiment of the present invention the film comprises a polymer of polyvinyl alcohol which is able to absorb water from the vapour or liquid phase to form a water-swellable gel.

20 In a further preferred form of the present invention the polyvinyl alcohol polymer is soluble in water above 80°C and insoluble in water below 40°C. It is further preferred that the polymer is free of low molecular weight compounds that exude from the polymer and form an aqueous solution when the polymer is equilibrated with atmospheres saturated with water vapour.

25 The first sheet may be composed of any number of materials which are impervious to liquid water and water vapour. At present, however, it is preferred that the second sheet comprises a film of polyethylene, polypropylene or a layer of wax.

30 In a further preferred form of the present invention the packaging material further includes a second sheet which is permeable to water vapour, the film being positioned between the first and second

1 sheets. The second sheet prevents the film from  
2 sticking to the horticultural commodity.

3 The second sheet can be composed of a number of  
4 hydrophobic or hydrophilic polymers such as the  
5 polyenes, polyvinyl chloride and fluorinated polymers.  
6 The physical state of the polymer should be such that  
7 it is freely or partly permeable to water vapour. In a  
8 preferred embodiment of the second sheet, it is  
9 composed of a hydrophobic polymer, such that while it  
10 is freely permeable to water vapour, it offers some  
11 resistance to the passage of liquid water. Materials  
12 that meet these specifications includes the non-woven  
13 fabrics made of polyethylene, such as "TYVEK" made by  
14 Dupont, non-woven fabrics of polypropylene such as  
15 "EVOLUTION" made by Kimberley Clark, or perforated  
16 films of these polymers, or papers or woven fabrics  
17 made from cotton or similar fibres, that have been  
18 treated to render their surface hydrophobic.

19 In yet a further preferred form of the present  
20 invention the packaging material further includes an  
21 outer layer, the first sheet and the film being  
22 positioned between the outer layer and the second  
23 sheet. The function of the outer layer is to provide  
24 mechanical strength to the packaging material and may  
25 be composed of a number of such materials well known in  
26 the field and will typically be a corrugated paper  
27 carton.

28 In a second aspect the present invention consists  
29 in a method of packing horticultural produce comprising  
30 wrapping the produce in the packaging material of the  
31 first aspect of the present invention such that the  
32 film is positioned between the produce and the first  
33 sheet.

34 In a preferred form of the present invention  
35 following the packing of the horticultural produce the

packaged material is cooled to the required storage temperature.

In order that the nature of the present invention may be more clearly understood preferred forms thereof will now be described with reference to the following examples and figures in which:-

Fig. 1 shows the water uptake and loss characteristics of the polyvinyl alcohol film at different relative humidities (■ drying; □ wetting) (Y-axis: grams of water per 100 grams dry polyvinyl alcohol);

Fig. 2 shows water uptake of the film which has been equilibrated at 100% relative humidity when placed in contact with liquid water (⊠ water as vapour; ■ water as liquid).

Figs. 3 shows a schematic representation of a prior art form of packing.

Figs. 4, 5 and 6 show schematic representations of preferred forms of the invention; and

Fig. 7 shows rate of water loss at 25°C from discs of absorbent paper (Whatman Number 1 filter paper) (—■—) and polyvinyl alcohol film (—□—).

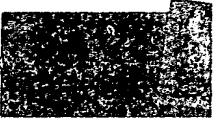
#### Preparation of a Polyvinyl Alcohol Film

Commercial film of polyvinyl alcohol was used that is insoluble in cold water but soluble in water above 80°C (Poval Type L, made by Kuraray). The thickness was about 50 microns. The film was washed by immersion and agitation in three changes of water at 20°C. The washing removed a compound of low molecular weight that had a high affinity for water and which "bled" from the original film at humidities above 80%. The washed film was dried at room temperature. This washed film remained free of liquid even when equilibrated to 100% relative humidity.

The water uptake and loss characteristics of the film at different relative humidities are shown in Figure 1.

5 The water uptake of the film, which has been equilibrated at 100% relative humidity when contacted by liquid water are shown for several samples in Figure 2.

10 The results show that, even after taking up water vapour from air at 100% relative humidity, the film is able to absorb significantly more water from the liquid phase into the gel phase of the film.

These characteristics contrast with the unwashed film, which deliquesces ("bleeds") when placed in a  at high relative humidity. As is well known, absorbent papers can also take up additional water from the liquid phase after being equilibrated at 100% relative humidity. In this case much of the water is taken up by capillary spaces rather than as gel phase water. Whether a film of polyvinyl alcohol or similar gel-like material is to be preferred over a paper-like material in the present invention is influenced by this difference in behaviour.

When warm horticultural produce is placed within a barrier to water vapour the air around the  
25 horticultural produce approaches a relative humidity that is in equilibrium with the horticultural produce. For most fresh produce, this will be about or above 98% relative humidity. When such a package is cooled, the vapour barrier will cool more quickly than will the  
30 bulk of the produce. Whenever the temperature of the water vapour falls below the dew point for the prevailing humidity, water will condense on the vapour barrier. This is the situation shown in Figure 3.

35 The use of the packing material of the present invention which includes a water absorbing film which can act as a reservoir of water and so control



condensation under fluctuating temperatures is to be contrasted with the use of sachets or local concentrations of gel particles in the packaging of horticultural produce. The distribution of water vapour within a package of horticultural produce in which there are gradients of temperature is limited by the rate of diffusion of water vapour. The diffusion limitation results from the relatively small differences of partial pressure for water vapour for a given difference in relative humidity. Accordingly, due to this diffusion limitation it is highly desirable that the water-absorbing material is as close as possible to the horticultural produce. This is very difficult to achieve with sachets of desiccants or humidity buffers which have a local influence only and fail to control humidity and condensation in more distant parts of the package. In contrast, in the present invention all areas of the package are close to the water absorbing film. Indeed, in a preferred embodiment of the second aspect of the present invention, if the package is bulky, a sandwich comprising a film, which is capable of absorbing at least 10% of its weight of water from liquid water after being equilibrated with an atmosphere saturated with water vapour, between two sheets which are permeable to water vapour is provided between each, or some of the layers of horticultural produce.

As will be readily apparent to those skilled in this field the packing material and method of the present invention provide clearly superior property over that of the prior art in which localised desiccants and humidity buffers are used.

In Figure 3 the produce is designated 10, the water vapour/liquid water barrier is designated 11 and an outer rigid packing material is shown as 12. As can

be seen in this drawing condensation droplets 13 form on the water vapour/liquid water impermeable layer 11.

As shown in Figure 4 when a water absorbing film 14 is included in the packaging material condensation is prevented from accumulating. Water vapour given off by the warm produce is absorbed into the film 14 and does not accumulate.

Figure 5 shows a further preferred form of the present invention in which the packaging material further includes sheet 15 which is permeable to water vapour. The inclusion of sheet 15 prevents the film 14 from sticking to the produce. This tends to be a problem when the film is fully hydrated and is prevented by the inclusion of sheet 15. In the embodiment shown even if the amount of water that is absorbed by film exceeds its capacity, sheet 15 prevents the passage of liquid water to the produce.

Figure 6 shows a further preferred form of the present invention in which the film 14 adheres closely to the vapour/liquid water barrier 11. In this example the vapour/liquid water barrier may be polyethylene which has been extended on to or laminated to the film 14 which may be an absorbent paper or other fibrous hydrophilic material. In the case illustrated in Fig. 6 the sheet 15 may be point bonded 16 to the paper 14, such that the bonded area does not exceed 5% of the total area.

In the examples illustrated by Fig. 5 and Fig. 6, the condensation which is sequestered in film 14 is able to evaporate and return to the horticultural produce through the vapour phase. The ease with which this occurs for two possible formulations of film 14 is shown in Fig. 7. If film 14 is polyvinyl alcohol, there is a rapid fall with time of the rate at which the stored water can evaporate. This may be advantageous if the package is subject to large

fluctuations in temperature. Alternatively, Fig. 7 shows that if the water is stored in a paper, uniformly rapid evaporation is possible over a more extended period. This may be advantageous when it is desired to allow as much as possible of the condensed water to return to the horticultural produce.

The rate of loss of water at 25°C was followed under conditions of constant water deficit from discs of absorbent paper (Whatman Number 1 filter paper) or polyvinyl alcohol film (Kuraray Poval Type L, washed) after saturating with water and blotting to remove surface moisture. The nearly constant rate for paper of the first 30 minutes reflects the loss of capillary-held water. In contrast, all the water in the polyvinyl alcohol film was held in the gel phase. As a consequence, most of the water was lost at a lower rate from this material.

The performance of the condensation control made with paper as the water storing agent (film 14 in Fig. 6) and incorporated into a box, is shown in Table 1. Boxes were made whose internal dimensions were height, 15.5cm; width, 29.5cm; length, 46.0cm. The water barrier 11 was polyethylene of thickness 12 micrometres bonded to an absorbent paper (14) of weight 50 grams per square metre. The layer 15 was composed of Evolution fabric made by Kimberley Clark Ltd, of weight 16 grams per square metre. This was point bonded to the paper with small pieces of double-sided sticky tape. These boxes were compared with ones in which the polyethylene liner 11 only was present. They were then loaded with carrots (6kg) that had been previously brought either to 22°C or 10°C. All the boxes were closed and placed in a coolroom at 3°C for 3 days. The quantity of free moisture which could be blotted with tissue paper from the insides of the boxes and from the carrots was then determined. Table 1

shows that the condensation control box was completely successful in eliminating free moisture with the lesser degree of cooling, and more than 95% successful in reducing free water accumulation with the greater amount of cooling.

5

TABLE 1

Condensation as free water recovered from box (ml)

5	Cooled from 10C to 3C		Cooled from 22C to 3C		
	Expt	Polyethylene Liner	Condensation Control	Polyethylene Liner	Condensation Control
10	1	9.9	0.0	23.4	0.1
	2	10.7	0.0	22.3	0.1
	3	10.0	0.0	22.3	0.0
	4	10.6	0.0	25.1	0.1
	5	9.3	0.0	21.4	0.9
15					

It will be appreciated by persons skilled in the art that numerous variations and/or modifications may be made to the invention as shown in the specific  
 20 embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive.

## CLAIMS:-

1. A packaging material for use in packing horticultural produce, the packaging material comprising a first sheet which is impermeable to water vapour and liquid water and a film which is capable of  
5 absorbing at least 10% of its weight of water from liquid water after being equilibrated with an atmosphere saturated with water vapour.
2. A packaging material as claimed in claim 1 in  
10 which the film comprises a layer of fibrous hydrophilic material.
3. A packaging material as claimed in claim 2 in which the film is paper made from cellulose fibres or other hydrophilic fibres.
- 15 4. A packaging material as claimed in claim 1 in which the film comprises a polymer of polyvinyl alcohol which is able to absorb water from the vapour of liquid phases to form a water-swellaable gel.
- 20 5. A packaging material as claimed in claim 4 in which the polyvinyl alcohol polymer is soluble in water above 80°C and insoluble in water below 40°C.
6. A packaging material as claimed in claim 4 or claim 5 in which the polyvinyl alcohol polymer is free of low molecular weight compounds.
- 25 7. A packaging material as claimed in any one of claims 1 to 6 in which the film is bonded to the first sheet.
8. A packaging material as claimed in claim 7 in which the bonded area is less than 5% of the total area  
30 of the film.
9. A packaging material as claimed in any one of claims 1 to 8 in which the first sheet comprises a film of polyethylene, polypropylene or a layer of wax.
10. A packaging material as claimed in any one of  
35 claims 1 to 9 in which the packaging material further includes a second sheet which is permeable to water

vapour, the film being positioned between the first and second sheets.

11. A packaging material as claimed in claim 10 in which the second sheet is composed of a hydrophobic polymer such that while it is freely permeable to water vapour it offers some resistance to the passage of liquid water.

12. A method of packing horticultural produce comprising wrapping the produce in the packaging material as claimed in any one of claims 1 to 11 such that the film is positioned between the produce and the first sheet.

## ABSTRACT

The present invention provides a packaging material for use in packaging horticultural produce. The packaging material of the present invention comprises a first sheet which is impermeable to water vapour and liquid water and a film which is capable of absorbing at least 10% of its weight of water from liquid water after being equilibrated with an atmosphere saturated with water vapour. In preferred forms of the invention the film comprises a layer of fibrous hydrophilic materials such as paper made from cellulose fibre or other hydrophilic fibres. Alternatively, the film comprises a polymer of polyvinyl alcohol which is able to absorb water from the vapour and from the liquid phase to form a water-swelling gel. The film may be bonded to the first sheet or it may be free. The present invention also provides a method of packaging produce involving the use of this packaging material.



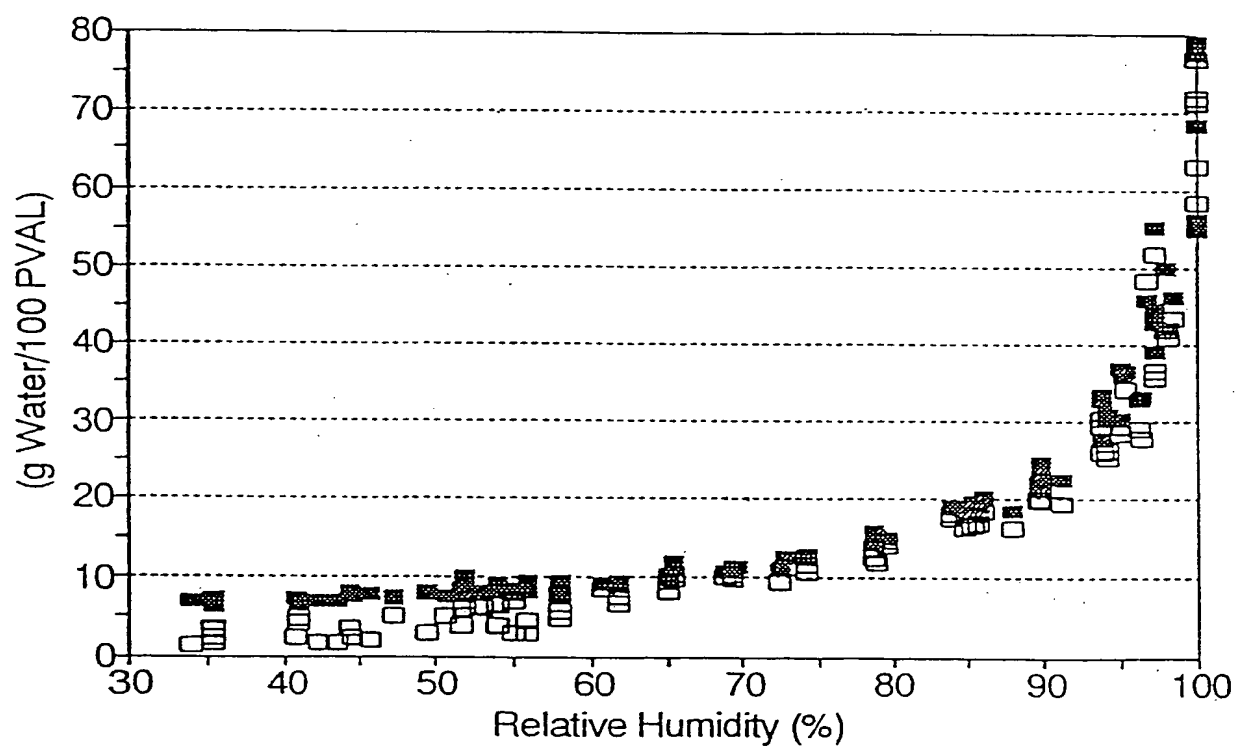


FIG. 1

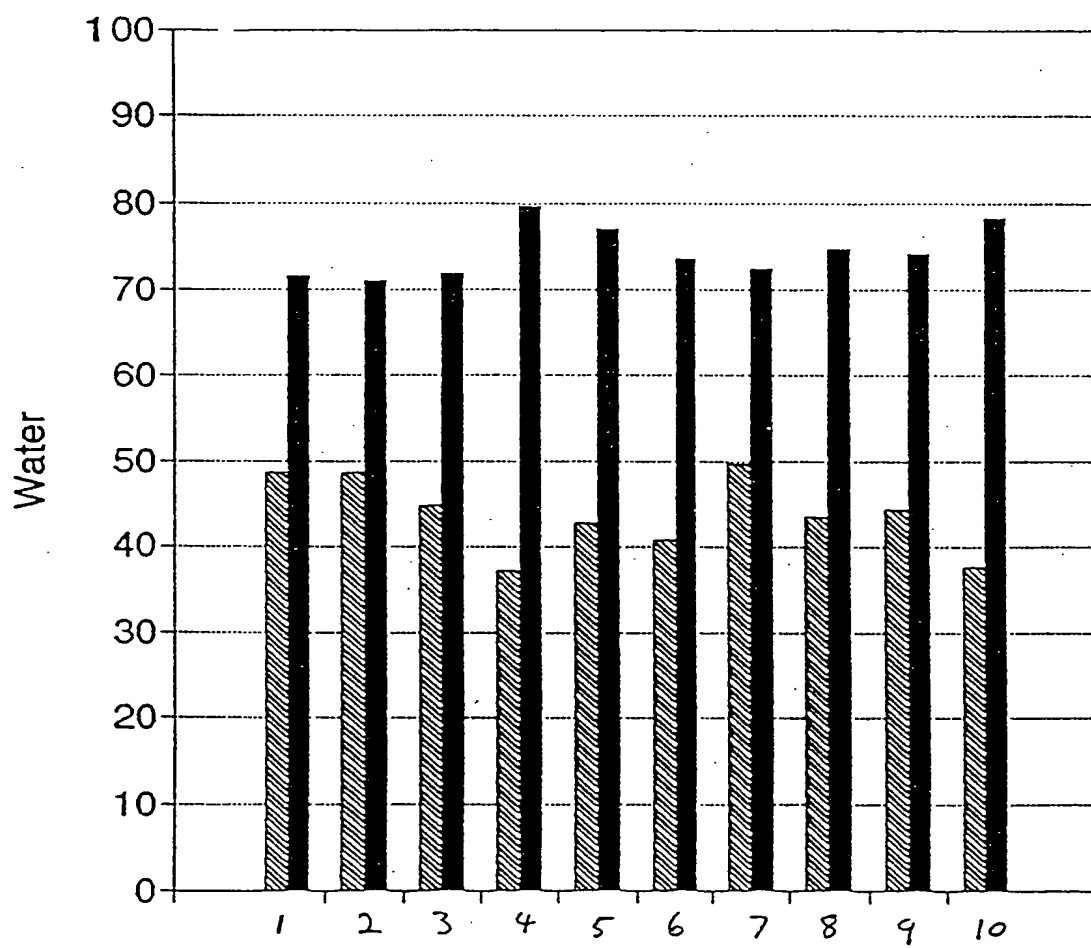


FIG. 2

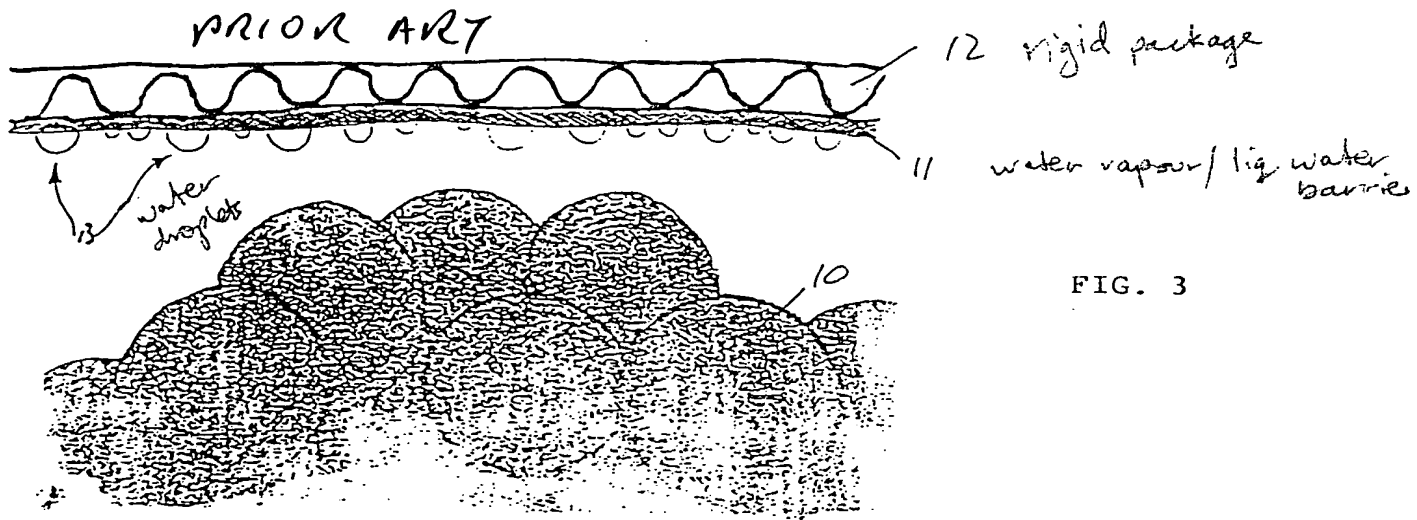


FIG. 3

FIG. 4

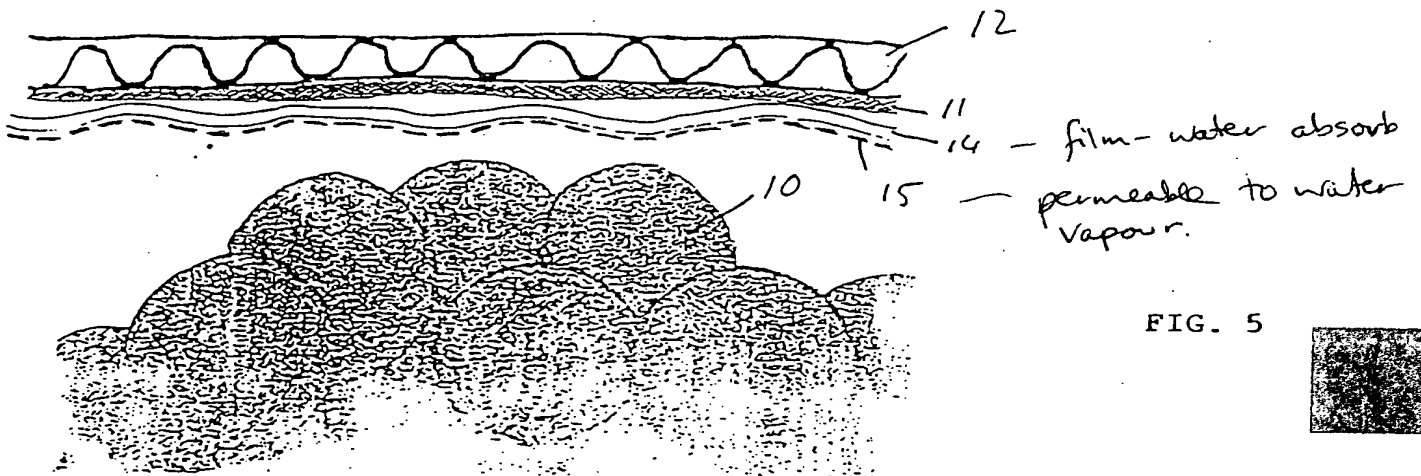
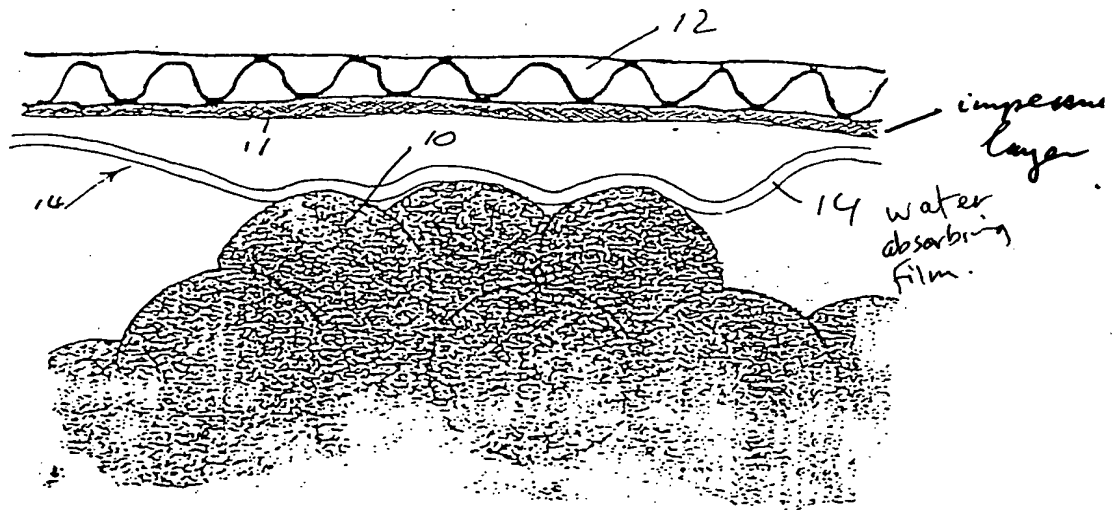


FIG. 5



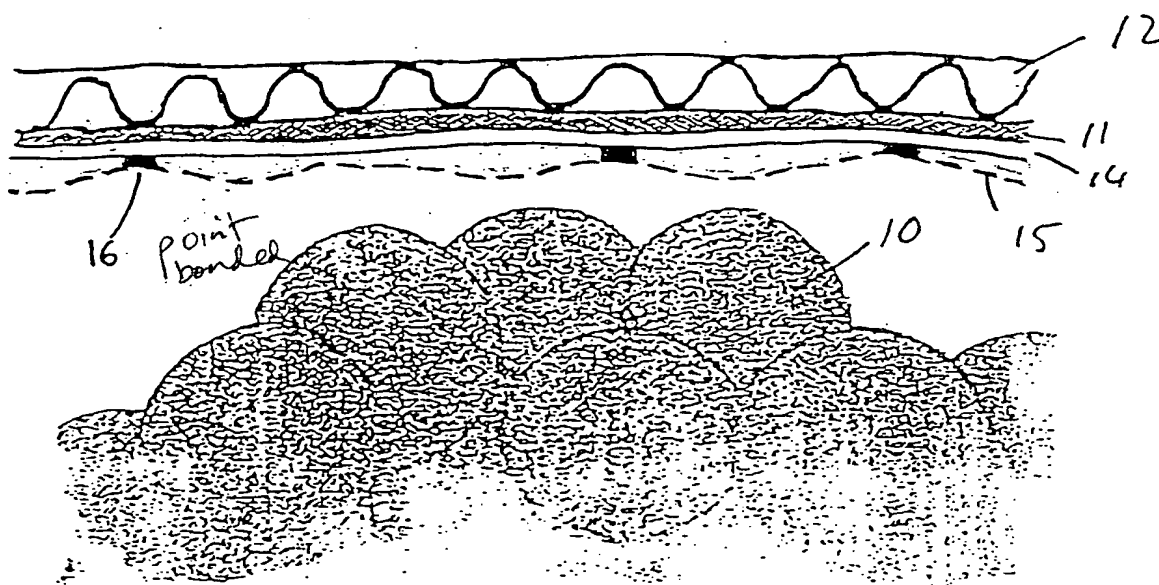


FIG. 6

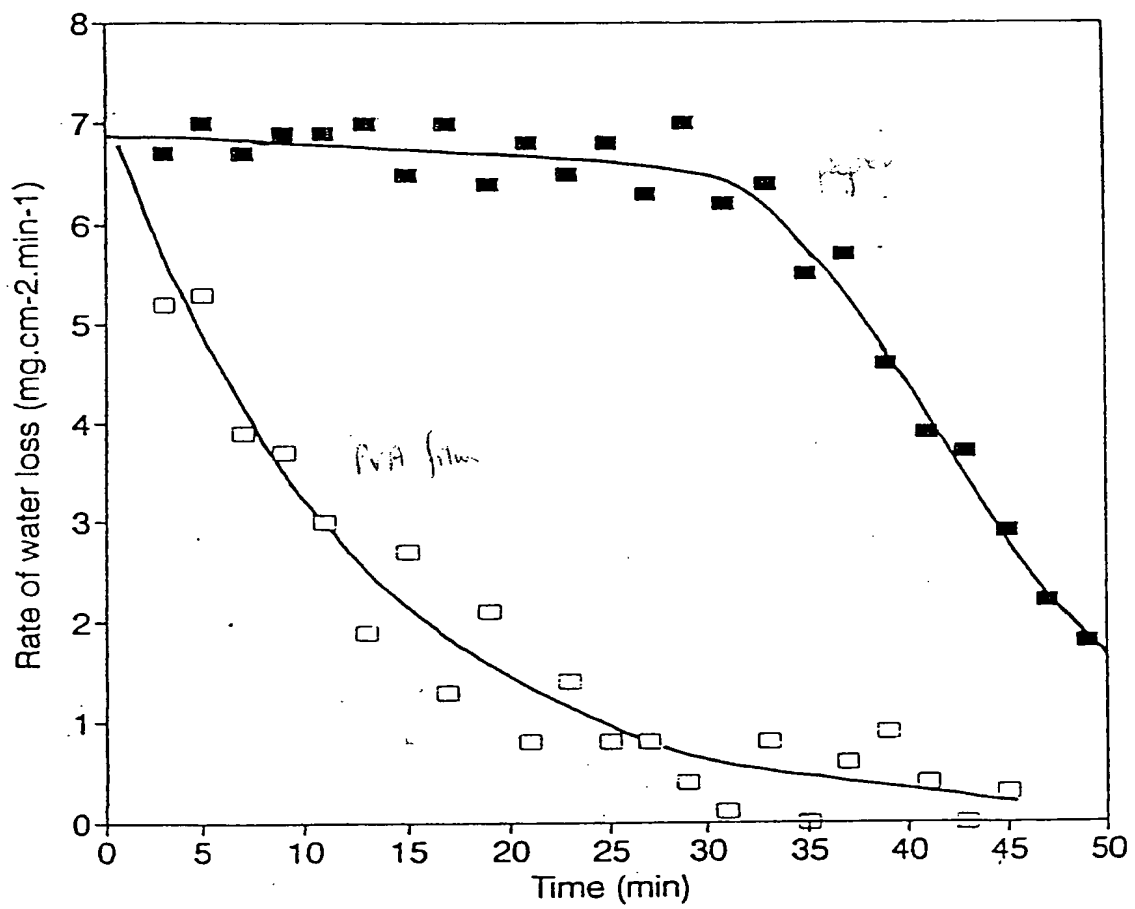


FIG. 7.